



Article

Marginal Bone Loss in Implants with External Connection versus Internal Conical Connection Prior to Prosthetic Loading. A Randomized Clinical Study

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Abstract: Introduction: The prosthetic connection of implants has been related to the loss of marginal bone. The aim of this study was to evaluate bone loss around external connection (EC) and internal conical connection (ICC) implants prior to prosthetic loading. Material and methods: A randomized clinical trial (RCT) was carried out, with a sample size of 93 implants (31 EC and 62 ICC) placed in 27 patients. Radiological controls were performed and stability was measured by resonance frequency analysis (RFA) on the day of placement, at 1 month and at 4 months after the placement. Results: Bone loss in EC implants was not statistically different than in ICC implants between the time of placement (T_0) and the subsequent month (T_1): (EC = 0.18 mm and ICC = 0.17 mm). Between one month (T_1) and four months (T_2): (EC = 0.39 mm and ICC = 0.19 mm) this difference was highly significant ($p = 0.00$). Bone loss between T_0 and T_2 was significantly lower in the ICC (EC = 0.57 mm and ICC = 0.36 mm), ($p = 0.01$). The overall success rate of the implants was 97.8%. The stability of the implants increased from 70.69 (T_0) to 73.91 (T_1) and 75.32 (T_2). Conclusions: ICC showed less bone loss up to the time of prosthesis placement. Such bone loss did not have a significant impact on bone stability. Long term RCTs are needed to demonstrate whether this bone loss, which is more pronounced at the beginning in EC, tends to stabilize and equate to ICC.

Keywords: external connection; internal connection; peri-implant bone loss; bone remodeling; preload prosthesis

1. Introduction

Replacing missing teeth with implant-supported prostheses, whether in totally or partially edentulous patients, allows better comfort and aesthetics [1] and restores functional levels similar to natural teeth [2,3].

The implant-prosthesis system usually has two components—the implant that is placed into the bone and is osseointegrated and the prosthesis that is attached to the implant directly or through an intermediate attachment.

At present, there are various connections to join the implant inserted to the prosthesis, and they can be grouped into two large groups: the external connection (EC) and the internal connection (IC). The external connection implant, designed by Branemark and Zarb in 1985, consists of a hexagonal

surface on top of the implant platform [4]. This connection was developed to facilitate the insertion of components such as abutments and impression copings, providing antirotation ability to the abutments [4]. The weakness of this system is attributed to the limited height of the hexagon (although subsequent modifications have been made), which means that when there is a high occlusal load or lateral forces, micro-movements of the abutment occur, which may cause loosening of the retention screw and in some cases their fracture [5–7].

In the internal connection, the connection is inside the implant. Within this large group, we find the conical internal connection (ICC) that can be Morse-taper or false Morse-taper. This type of adjustment, used in industrial applications, consists of an internal inverted cone geometry that induces a self-locking mechanism by pressing between the implant and the abutment. This connection is also characterized by having a stem that follows the cone and provides stability [8]. In oral implantology, ICC has gained a strong reputation in recent years [9] due to its mechanical stability and low percentage of loosening of screws. It has been shown that in ICC, stress is transmitted to the most apical area which results in less stress on the crestal bone [10,11]. In addition to this design, the concept of platform switch can be added, which refers to the displacement of the implant-abutment junction towards the center of the implant in order to isolate bacterial leakage towards the crestal bone [12]. This system preserves the soft and hard tissue, achieving better aesthetic results [13]. However, other clinical studies found no significant difference in bone loss as a result of the platform switch and established that more research is needed to determine if its use is more effective [14,15].

On the other hand, according to some studies, the complications that could occur in this type of connection are due to the axial displacement of the abutment when subjected to axial masticatory forces. Thus, complications such as implant fractures could occur in the coronal area if they are subjected to a high occlusal load [16,17].

Currently, loss of 1.5 mm of bone insertion in the first year and 0.2 mm in the following year, which was previously assumed to be normal [18], has been reduced to ≤ 1 mm per yearly follow-up, as demonstrated by a large number of recent clinical studies. Some of these clinical studies [19–27] are included in systematic reviews and meta-analyses, evaluating bone loss around implants [28–30].

There are multitudes of factors to which bone loss can be attributed such as the type of connection and the location of the implant with respect to the bone [17]; establishment of a biological width [31,32]; lack of fit and passivity, as well as errors in the manufacturing process [33]; inadequate dimensions of the implants [34]; bacterial filtration, peri-implantitis caused by different potential etiologic agents [35–37]; micro-gaps between implant-abutment [38–41]; occlusal overload [42–44]; and surgical trauma caused during implant placement [45]. Thus, it could be considered that there are multiple causative factors of bone loss; but over the years, several authors have described that the type of connection chosen plays a fundamental role in preservation or loss of bone in the future [46–48]. For this reason, Almeida et al. [49] described that after osseointegration, the implant connection is responsible for the success of prosthetic rehabilitation [49,50].

In a recent systematic review, it was concluded that both connections have high survival rates, although the internal connection appears to show less bone loss in a large number of implants. To assess whether bone loss differs significantly between the two connections, more homogeneous clinical studies are needed in which the characteristics of the implants are the same between each group [51].

The objective of the present study was to determine if bone loss is different in EC and ICC implants at the time of prosthesis placement. PICO format: Patient, partially edentulous; Intervention, dental implant with ICC; Control, dental implant with EC; Outcome, bone loss.

2. Materials and Methods

This clinical trial focused on answering a PICO format [52]. In patients treated with different implants connection, are there differences between EC and ICC in terms of bone loss?

2.1. Study Population

A randomized split-mouth clinical study was carried out at the University of Barcelona Dental Hospital. All participants were recruited from this center from May 2017 to November 2018. This was approved by the Ethics and Clinical Research Committee of the University of Barcelona Dental Hospital (CEIC HOUB ethics committee). The criteria of the CONSORT guidelines were taken into account for conducting clinical trials and were included in the ClinicalTrials.gov database of clinical studies, ID: NCT03232372. Patients of legal age who presented total or partial edentulism in the mandible and/or maxilla, with at least two teeth missing in the same jaw, were included. The teeth had to have been extracted at least 4–6 months before implant placement. The minimum bone height had to be 8 mm, which was determined by a Cone Beam Computer Tomography (CBCT) in all cases, prior to inclusion in the study. The area where the implants were to be placed had to have sufficient bone volume without any need for bone regeneration (bone width > 7 mm). The minimum distance from an implant to adjacent teeth had to be at least 1.5 mm, and at least 3 mm in the case of two or more adjacent implants. Patients with a history of treatment with Bisphosphonates or other antiresorptive medicines, evidence of serious systemic diseases such as recent cardiac infarction, uncontrolled diabetes, coagulation disorders, cancer, psychiatric contraindications, active infection in the implant zone, absence of antagonist teeth, treatments with pharmacological agents capable of affecting gingival health and pregnant or lactating women were excluded.

2.2. Study Data

The following variables for each patient were included: i. family pathological history; ii. personal history; iii. allergies (including allergy to titanium); iv. toxic habits; in case of smokers, number of cigarettes per day; v. current medication; vi. height; vii. sex; viii. weight; ix. parafunctional habits; x. frequency of brushing; and xi. flossing. An intraoral examination was also performed where absence of teeth, previous dental treatments, plaque index, probing depth, mesial and distal contact of the area to be implanted and type of teeth or antagonist prosthesis were recorded. Once the implants were placed, the following were evaluated: radiographic control, control of soft tissues, control of exposure of the cover screw, presence of inflammation and bleeding or suppuration.

2.3. Study Design and Randomization

A classic split-mouth study was not proposed in this research because the recruitment of patients could have been complicated due to the need for symmetrical edentulous patterns. Instead, we adopted the methodology proposed by Lesaffre et al. [53], in which an inclusion criterion that the patients presented at least two edentulous spaces in the same jaw was applied. It was planned in this way based on the difference in the ossification pattern of the mandible and the maxilla [21], which could induce a bias when comparing bone loss. Prior to surgery, the researcher (N.P.-G.) carried out the randomization and assignment of the implants through an application that generates random numbers (Random N—Version 4.2, 2015). In each jaw, each edentulous space was assigned a random letter (A, B, C, ...). Following the alphabetical order, each letter was randomly assigned to the corresponding connection. Randomization was carried out among three groups because we wanted to collect information on bone loss in ICC implants placed at different vertical positions with respect to the crestal bone. Thus, the three groups obtained were: (1) internal connection-crestal level, (2) internal connection-subcrestal level and (3) external connection (always placed at the level of the crest). With respect to the study reported in this article, when investigating only the type of connection, the data from the internal connection groups (1) and (2) were treated jointly.

Subsequently, a statistical analysis was carried out to assess whether the bone loss differed between the connections and the vertical position of the implant.

2.4. Sample Size Calculation

To test the hypothesis on the difference in bone loss in implants with internal connection vs. implants with external connection, the following formula was used to quantify the size of the sample required.

$$n = \frac{2(Z_{\alpha} + Z_{\beta})^2 \times S^2}{d^2} \quad (1)$$

where: n = number of subjects needed in each of the two groups (i.e., internal vs. external); Z_{α} = Z-value correspondent to the desired level of risk of falsely rejecting a true null hypothesis; Z_{β} = Z-value correspondent to the desired level of risk of failing to reject a false null hypothesis; S = Standard deviation in mm of bone loss in implants with internal connection; d = Minimum desired value in mm of the difference in bone loss between the two groups.

Thanks to the review of the literature, we knew that in previous studies the standard deviation in bone loss in internal connection was approximately 0.35 mm and that we would obtain a significant difference between the two treatments by achieving a difference in bone loss of approximately 0.25–0.30 mm.

We accept a risk of 5% and a statistical power of 95% to detect differences, if they exist.

Finally, based on a recent systematic review [51], in which, from a qualitative point of view, no differences were identified between the two connections for randomized clinical studies with a larger sample number and greater longevity, we postulate a two-tailed hypothesis testing.

Substituting the data into the formula, we obtained that for each group (ICC and EC) we would need a minimum sample size of 28 observations.

2.5. Surgical Intervention and Clinical Follow-Up

The same surgical protocol was followed in all cases: 2-min rinses with 0.2% chlorhexidine (Bexident Post® ISDIN SL., Barcelona, Spain), local anesthesia with 4% Articaine with 1:100,000 Epinephrine (Inibsa®, Lliça de Vall, Barcelona, Spain) and crestal incision and full-thickness mucoperiosteal flap. The implants placed were ETK® brand (Barcelona, Spain), EC: Uneva® implant (Barcelona, Spain) and ICC: Naturactis® (Barcelona, Spain) and Naturall® (Barcelona, Spain) (Figure 1).

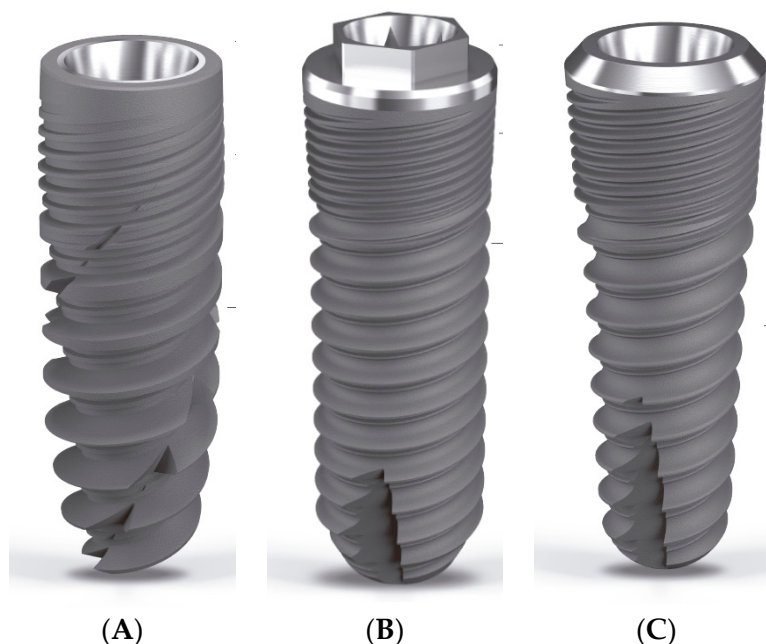


Figure 1. Type of implants. (A) Naturactis®: internal conical connection (ICC) subcrestal-level; (B) Uneva®: external connection (EC) crestal level; (C) Naturall®: ICC crestal level.

All the implants had the same surface type: micro-sandblasting of titanium oxide and etching with nitric and hydrofluoric acid from the apex to the implant neck. The platform switch was present in the ICC implants. The drilling sequence was carried out in accordance with the manufacturers' guidelines taking bone quality into account. All implants were placed with the motor programmed at 32 rpm and 35 Ncm, and the torque was noted according to the surgical perception of the surgeon. The implants were placed by 3rd year students of the Masters of Oral Medicine, Surgery and Implantology at the University of Barcelona. An implant placement order protocol was established, always starting with the 4th quadrant, followed by the 1st, 2nd and 3rd quadrant. The position of the implant, whether placed adjacent to an edentulous or non-edentulous space, was also registered. The entire procedure was supervised by N.P.-G. and J.L.-L.

Regarding the healing period, the second surgery was performed 105 days after the implant placement, and a healing abutment was installed for two weeks. The prostheses could vary between single crowns or fixed dental prostheses (screw retained and metal ceramic) and overdentures (metal resin with Locator[®] attachment system, Zest Dental Solutions, Carlsbad, CA, USA).

2.6. Implant Success Criteria

According to the clinical and radiographic criteria of Buser and Weber [54], the success or failure of each implant is analyzed at the time of placement of the healing abutment. I. absence of subjective complaints such as pain, foreign body sensation and/or dysesthesia; II. absence of recurrent peri-implant infection with suppuration; III. absence of mobility; IV. absence of continuous radiolucency around the implant; V. if restoration is possible [54].

2.7. Radiographic Monitoring of Bone Loss

Standardized orthopantomographs were realized at the time of implant placement (T_0), one month after implant placement (T_1) and four months after implant placement, prior to the prosthetic procedures (T_2). The measurements were performed using the Planmeca Romexis[®] software (version 5.0.R) to process 2D images generated by the X-ray units. Their analysis tools ensured that the calibration carried out prior to the measurements was correct, and this was verified taking into account the length of each implant. Since all patients required a CBCT prior to surgery, it was decided to not perform cone beam radiographs to limit multiple exposures to radiation. To perform the measurements, two visible landmarks were selected on the implant platform and a straight line was drawn joining them to represent zero height. Afterwards, a perpendicular line was drawn mesial and distal to the implant, from zero height to contact with the bone. If the implant was at coronal level with respect to the bone, the result would be interpreted as negative, whereas, if the implant was in the infracrestal position, the result would be positive. The difference between the mean of the mesial and distal measurements at the different times was used to calculate bone loss (Figure 2).

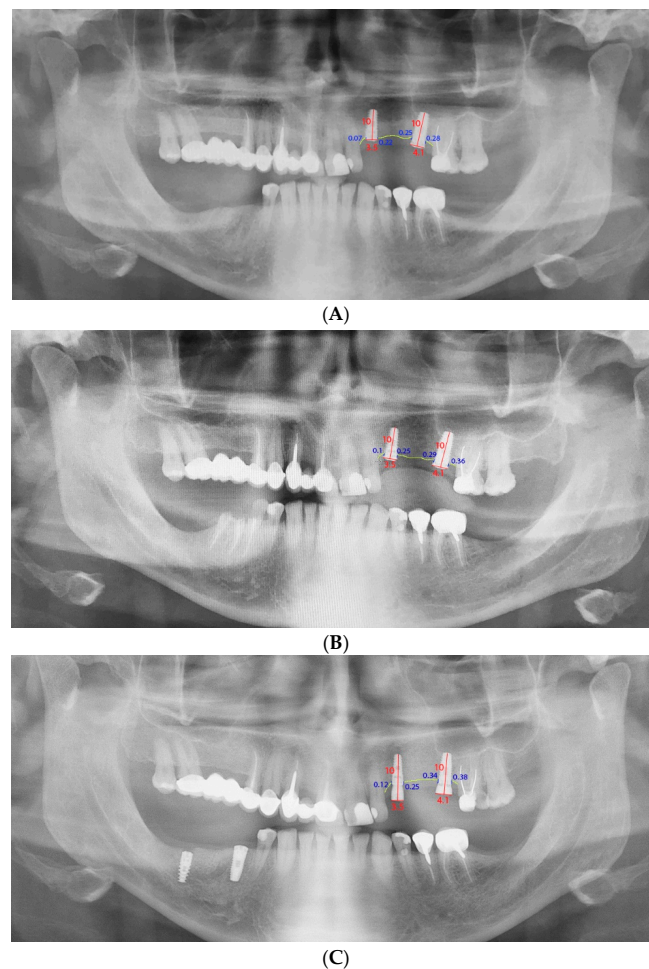


Figure 2. Measurement of periimplant bone loss. (A) After implant placement; (B) after 1 month; (C) after 4 months.

2.8. Resonance Frequency Analysis (RFA)

In this study, implant stability measurements were performed using RFA with the Penguin RFA[®] device (Penguin RFA, Klockner, Barcelona, Spain), at three occasions. The day of implant placement, when the healing abutment was placed (second stage) and at the time of prosthesis placement. Two measurements were performed for each implant: vestibular-palatal from the vestibular side and mesio-distal from the mesial side. The registration times were based on the study carried out by the group of Pozzi et al. [48].

2.9. Restorative Procedures

Silicone impressions were obtained two weeks after the second surgery (T2). Mainly, in the implants indicated for single crown, a porcelain fused to metal restoration was screwed at 30 N directly to the implant two weeks after impressions. In the implants indicated for a fixed dental prostheses, an abutment was screwed to the implant at 30 N, and a porcelain fused to metal superstructure was screwed to the abutments two weeks after impressions. The implants indicated for an overdenture, received a machined titanium abutment at 30 N, two weeks after impressions.

2.10. Single-Blind Study

For better reproducibility, the X-ray examiner (N.P.-G.) performed all the measurements on the radiographs and was different from the surgeons who placed the implants; thus, the distortion bias of the measurements could be reduced.

In addition, the patients were unaware of the type of connection and the position in which each type of implant was placed.

2.11. Statistical Analysis

The data were entered in Excel and processed using the statistical package STATA 14.0 (StataCorp LLC, College Station, TX, USA). A descriptive analysis of the qualitative and quantitative variables was carried out.

The Kolmogorov–Smirnov test was used to analyze if the distribution of measurements was normal, and the relationship between bone loss and the type of implant connection was analyzed using the parametric t-test. The level of statistical significance chosen was 5% ($\alpha = 0.05$).

A multiple linear regression analysis was used to evaluate the association between the dependent variable bone loss from T0 to T2, and the independent variables, ICC or EC. All the variables that were considered to potentially affect the study relationship were used as control variables in the regression, such as age, sex, smoker: number of cigarettes per day, jaw type, implant stability quotient (ISQ) measured by RFA, implant insertion torque, contacts on the mesial and distal side of the implant.

3. Results

3.1. Data Referred to Patients

A total of 27 patients (12 women and 15 men) participated in this study with a mean age of 56 years. None of the patients dropped out of the study. In total, 26% of the patients were smokers (4 women and 3 men), of which 2 smoked more than 20 cigarettes/day, 1 patient between 11 and 15 cigarettes/day, 3 patients between 6 and 10 and 1 patient less than 5 cigarettes/day. Regarding the frequency of brushing, 19% of the patients reported brushing their teeth 2–3 times a day, 67% 1–2 times a day and 15% not once a day. In total, 89% patients presented partial edentulism and 11% total edentulism.

3.2. Data Referring to Implants

After implant placement, complete wound closure was achieved in all cases. Prior to performing the second stage surgery, 68% of EC implants had the implant cover screw exposed or semi-exposed, compared to 17% for ICC (Figure 3).

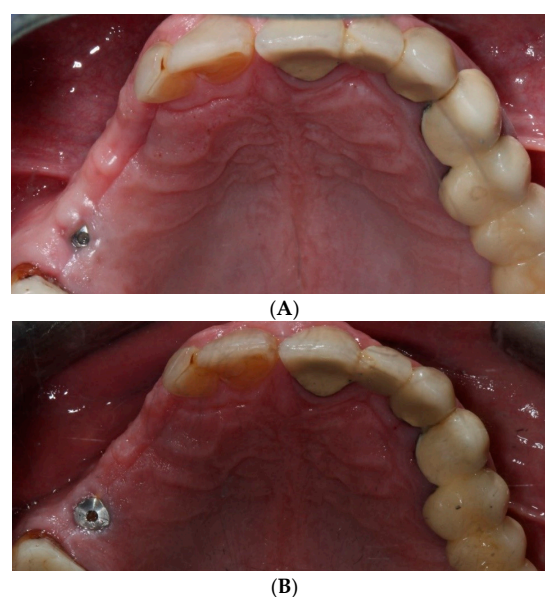


Figure 3. (A) EC implant, cover screw one month after placement; (B) EC implant, cover screw 3 months after placement.

The sample size was 93 implants (31 from EC placed at crestal level and 62 from ICC: out of which 33 were placed at infracrestal level and 29 at crestal level). In total, 60% of the implants were placed in the mandible and 40% in the maxilla; 52% were placed in molars, 28% in premolars and 20% in incisors.

Three patients received overdentures with Locators® (Carlsbad, CA, USA) attachment in the mandible. The rest were restorations with single crowns and fixed prostheses (Table 1).

Table 1. General implant data.

General Implant Data		Total
93 implants	Maxillary	40%
	Mandibular	60%
At the molar level		52%
At the premolar level		28%
At the incisor level		20%
27 patients	24 patients	Crowns and bridges
	3 patients	Overdentures

3.3. Implant Success and Survival

Two implants presented mobility at the time of placement of the healing abutment and were explanted. Survival and success rates were obtained in accordance with Buser's clinical and radiological criteria of 97.8% [54]. Of the two failed implants, one was external connection and the other was internal connection. Both were placed in the mandible, one in the canine-premolar area and the other in the molar area.

3.4. Bone Loss

Between the first (T_0) and the second measurement (T_1) reported on the left side of the table, the average bone loss in ICC implants was 0.17 and 0.18 mm in EC implants, resulting in no significant differences (p -value = 0.79).

Between the second (T_1) and the third measurements (T_2), the mean was 0.19 mm for ICC implants and 0.39 mm for EC implants, this difference being statistically significant (p -value < 0.001).

Total bone loss from implant placement (T_0) to the third measurement (T_2) was 0.36 and 0.57 mm, respectively, for the ICC and EC implants. This difference was statistically significant (p -value = 0.01) (Table 2; Figures 4–6).

Table 2. Bone loss in internal and external connection.

Connection Type	T_0 – T_1			T_1 – T_2			T_0 – T_2		
	Mean	SD	95% CI	Mean	SD	95% CI	Mean	SD	95% CI
ICC	0.17	0.28	0.1–0.24	0.19	0.17	0.15–0.24	0.36	0.34	0.3–0.45
EC	0.18	0.21	0.1–0.26	0.39	0.24	0.3–0.48	0.57	0.37	0.4–0.71
t -test	−0.26	–	–	−4.4	–	–	−2.74	–	–
p -value	0.79	–	–	0.00	–	–	0.01	–	–

ICC: internal conical connection; EC: external connection; SD: standard deviation; CI: confidence interval; T_0 : day of implant placement; T_1 : one month after placement; T_2 : prosthetic restoration.

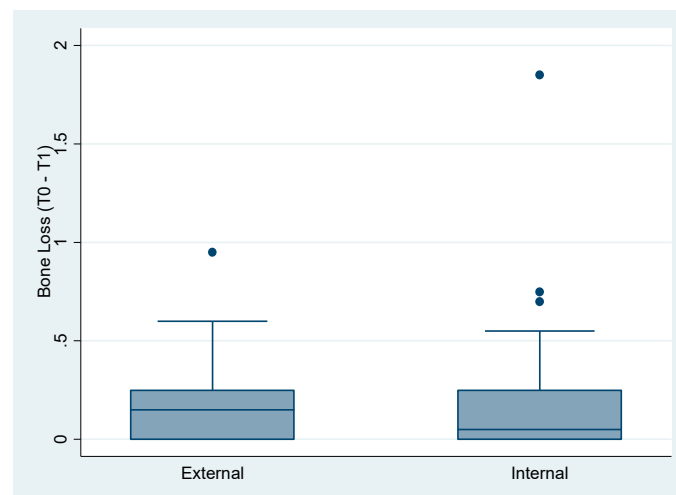


Figure 4. Bone loss (mm) in internal vs. external connection implants between the first and second measurements ($T0-T1$).

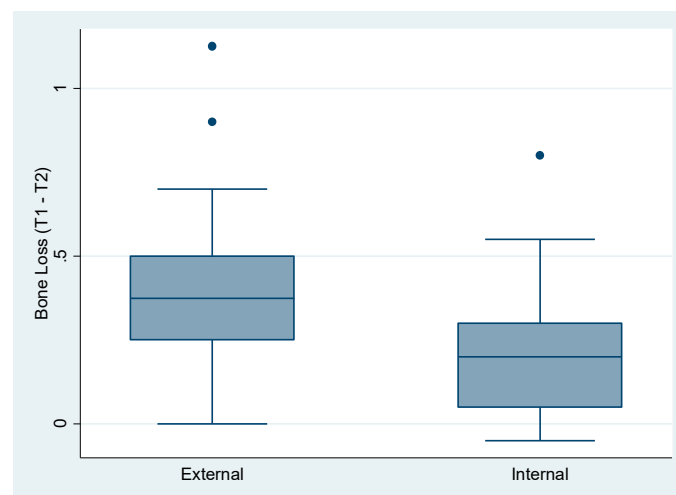


Figure 5. Bone loss (mm) in internal vs. external connection implants between the second and third measurements ($T1-T2$).

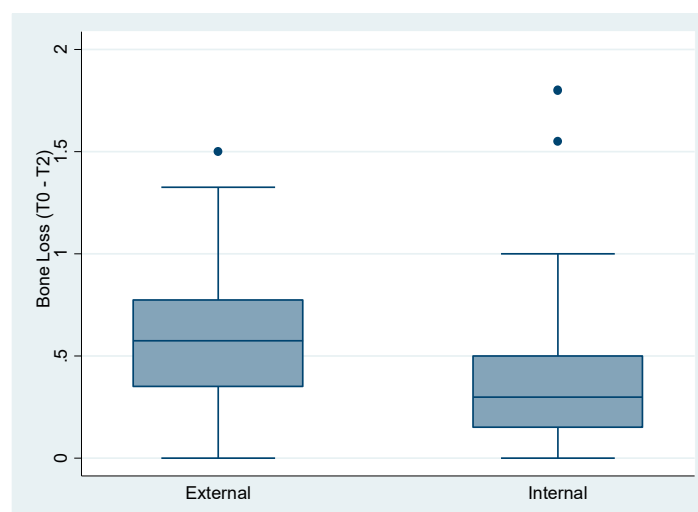


Figure 6. Bone loss (mm) in internal vs. external connection implants between the first and third measurements ($T0-T2$).

3.5. Resonance Frequency Analysis (RFA)

The first ISQ measurement on the day of implant placement refers to the primary stability obtained following the surgical act, and the following measurements refer to the secondary stability obtained during the osseointegration process. A mean of the vestibulo-palatal and mesio-distal measurements was calculated for each implant.

Measured values increased as the implant osseointegration period progressed (T0: 70.69; T1: 73.91; T2: 75.32) (Table 3, Figure 7).

Table 3. ISQ values.

Time of Measurement	Mean	SD	95% CI
ISQ T0: Day of implant placement	70.69	9.67	68.7–72.7
ISQ T1: Day of placement of the healing abutment (second stage)	73.91	7.19	72.4–75.4
ISQ T2: During the prosthetic restoration	75.32	6.15	74–76.6

SD: standard deviation; CI: confidence interval.

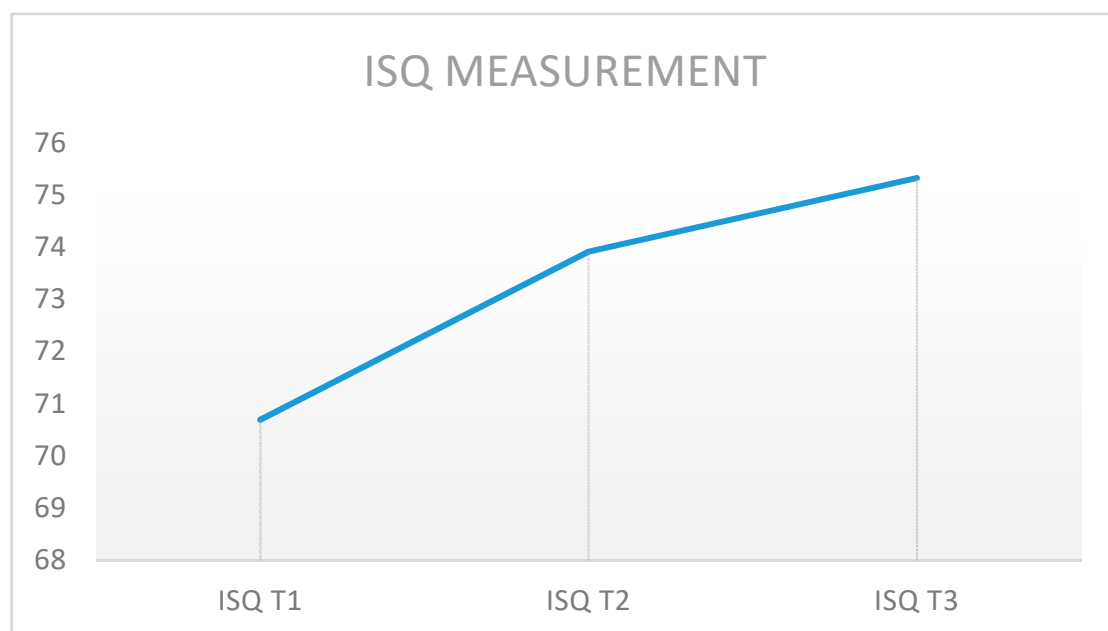


Figure 7. ISQ values measured at the three occasions.

There were two implant failures out of 93 placed, which were detected on the day of the second stage, prior to the second ISQ measurement. These two implants had a favorable ISQ on the day of placement. No further implant failures were registered after the second ISQ measurement.

There is no relationship between RFA values and bone loss; the results of the linear regression are shown in Table 4.

In the analysis of other possible determinants that may influence bone loss, no significant differences were found in relation to age, sex, jaw or maxilla, vertical placement of the ICC implant and tobacco consumption, considering implants of both type of connections (Table 4).

The torque obtained after implant placement was analyzed using the surgeon's perception. In Table 4, the options from 0 to 2 were considered as low torque and from 3 to 10, high torque. Of the 93 implants placed, 60 implants had high torque and 33 implants had low torque. Of these 33, only one showed slight mobility once placed, 13 continued to rotate when they entered the implant bed and in 19, the motor programmed at 35 Ncm stopped just when the implant was fully inserted (Table 5).

Table 4. Determinants of bone loss between T0 and T2.

Variable	Coefficient
1. Connection Type (Internal)	−0.29 *
2. Implant Placement (Subcrestal)	0.05
3. Gender (Male)	−0.04
4. Age	−0.01
5. ISQ T0	0.00
6. ISQ T2	0.00
7. Smoker (<5 cigarettes)	−0.08
8. Smoker (5–10 cigarettes)	0.01
9. Smoker (10–15 cigarettes)	−0.04
10. Smoker (15–20 cigarettes)	−0.07
11. Smoker (>20 cigarettes)	0.06
12. Maxilla (Mandible)	−0.06
13. Implant Insertion (Good surgeon perception)	−0.07
14. The implant contacts distally with the non-edentulous area	−0.19 *
15. The implant contacts mesially with the non-edentulous area	0.00
Constant	1.68 *
Prob > F	0.02
R ²	0.29

* 5% significance level; Constant: value at which the regression line crosses the *y*-axis; Prob: probability; *F*-value: determines whether adding each of the independent variables improves the regression model; R²: proportion of the variance for a dependent variable explained by the independent variables.

Table 5. Implant torque at the time of insertion.

Insertion of the Implant with the Motor Programmed at 35 Ncm Initially
0. Low implant stability (can be rotated with manual torque)
1. The motor stops when the implant is fully inserted
2. The motor does not stop and the implant continues to rotate within the implant bed
3. The motor stops, the Ncm is increased in the motor (max 50 Ncm) and the insertion continues with the motor
4. The motor stops and the ratchet insertion continues (1 to 2 turns)
5. The motor stops and the ratchet insertion continues (2 to 3 turns)
6. The motor stops and the ratchet insertion continues (3 to 4 turns)
7. The motor stops with several turns missing and is removed for further implant bed preparation. It is then introduced with motor increasing the Ncm
8. The motor stops with several turns missing and is removed for further implant bed preparation. It is then introduced with motor and the last turns with ratchet
9. The implant is mobile and is removed to place another one with a larger diameter. It is then introduced with motor increasing the Ncm
10. The implant is mobile and is removed to place another of a larger diameter. It is then introduced with motor and finished with ratchet

4. Discussion

The main finding of the present study is that implants with EC lose significantly more bone compared to those with ICC until the moment of prosthetic connection, as found by other recent studies

with few months of follow-up [46–48,55]. However, these findings should be taken with caution since there is the possibility that this bone loss, which does seem to be more pronounced during the first year in EC, tends to stabilize and equate to ICC. This occurs in the results of the study by Esposito et al. [55], where bone loss was greater in EC implants compared to ICC implants during the first year of follow-up (0.98 and 0.85 mm, respectively), although not significantly. Five years later, in another article published by the same research group, they found that implants with ICC had lost more bone than those with EC, although the difference was still not significant (EC: 1.13 mm and ICC: 1.21 mm) [56]. Continuing along the same lines, if we assess bone loss in longer studies, we find that several randomized clinical trials (RCTs) do not find differences when follow-up is longer, as in the case of Crespi et al. [57] (24-month follow-up), Arnhart et al. [27] (36-month of follow-up) and Cooper et al. [25] (36-month follow-up).

A hypothesis as to why bone resorption is more pronounced during the first year could be due to bone remodeling, which in turn is influenced by a variety of factors, including facilitating the formation of biological width, with the aim of creating a barrier “against” oral flora [58]. The biological width process begins on the same day as the implant placement, if a healing abutment is placed immediately and the implant is exposed to the oral environment (one stage), or at a second moment if the abutment is placed later (two stages) [59]. We could speculate that in EC implants, this remodeling could be anticipated, since the design of these implants has a hexagonal surface on top of the platform that measures 0.7 mm in height. The hexagon is covered by the cover screw, resulting in a combined height of the components that might cause the cover screw to be exposed or slightly exposed to the surface in the case of patients with thin gingival biotype, stimulating the initiation of bone remodeling necessary for the establishment of a biological width. In our study, 68% of EC implants were exposed to the oral environment prior to the second stage, and it is likely that bone loss was influenced by this fact. In implants with ICC, due to its design, little gingival thickness is required, so that the implant is completely submerged until the second stage 3 to 4 months later. This fact could explain why bone loss is greater in EC implants prior to prosthesis placement.

Despite advances in research, there is still controversy between the use of different connections, and we cannot forget that implants with EC have a long history and longer clinical studies that show that it is a reliable connection [1,51,60]. The studies conducted by Jacobs et al. [61] with 16 years of follow-up and by Ravald et al. [62] with 12–15 years of follow-up compared bone loss between implants with EC and ICC, and they found no statistically significant differences.

Regarding the RFA of the implants, it is considered that the values obtained were high the three times they were measured. A trend towards an increase in the average of the measurements could also be observed as the period of osseointegration of the implants progressed.

The two failed implants were detected on the day of the second stage prior to the second ISQ measurement (T1). These two implants had a primary stability classified as high insertion torque and an average RFA value of 79.5 and 76 on the day of placement. With this information, we could conclude that the values detected on the day of implant placement did not determine relevant results regarding implant survival. In this study, no more implant failures were recorded after the second RFA measurement; thus, the values obtained during the placement of the healing abutment could give us predictable information on the prognosis of the implant. These findings coincide with those of Rodrigo et al. [63], who studied the relationship of the diagnosis of implant stability and its impact on implant survival, reaching the conclusion that contrary to the RFA values of primary stability, only the values of secondary stability were able to significantly predict the prognosis of the implants [63].

The main limitation of this study is the short-term follow up (about 4 months) that does not provide complete information with respect to the typical behaviour of bone biology during a larger period of time.

Moreover, the different prosthetic indications and materials used could have an effect on the possibility of marginal bone loss. Although, to account for it, all the measurements were performed prior to the prosthetic procedures.

We are also aware that implant placement performed by more than one operator could affect the results. However, we believe that this fact can also be positive, since the same protocol was always followed and the results obtained did not depend on the possible experience and/or preference of the operator.

The survival and success rate of the implants in this study (97.8%) is similar to the current survival rate described by Pjetursson et al., who declared that in the last decade, the survival rate of implants has increased from 93.5% to 97.1% [64].

With respect to smoking and number of cigarettes smoked daily, it is known that tobacco has a negative influence, since it contributes to a greater number of implant failures, postoperative infections and marginal bone loss than in the case of non-smoking patients [65]. In our study, smoking patients did not have greater bone loss compared to non-smokers. However, in this study, the vast majority of patients were non-smokers and the follow-up time was short, so reliable conclusions cannot be drawn.

In our study, no differences were found with respect to bone loss and jaw type. Over the years it has been suggested that implants placed in the mandible have higher survival rates than those of the maxilla. The difference between bone qualities is considered to be the basic cause for the difference in survival rates [66].

Current research continues to try to figure out what may cause this bone loss, which is more pronounced in the first months after implant placement. It could be considered that there are multiple factors causing bone loss, and there may be situations where several factors are present at the same time and, on the contrary, other situations where they appear independently. This fact makes it difficult to attribute bone loss to one individual factor, since it is difficult to isolate only one parameter for analysis.

5. Conclusions

Taking into account the limitations of this study, particularly regarding the short follow-up period, it can be suggested that in implants with the similar surface, those with ICC show significantly better results regarding bone loss than those with EC (EC = 0.57 mm and ICC = 0.36 mm). RFA stability values were not related to bone loss.

In implants with both connections, appropriate clinical results were obtained and a survival rate of 97.8% was obtained.

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